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Plethodon longicrus, a New Salamander (Amphibia: Plethodontidae) From North Carolina

Kraig K. Adler and David M. Dennis

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PLETHODON LONGICRUS, A NEW SALAMANDER (AMPHIBIA: PLETHODONTIDAE) FROM NORTH CAROLINA

Kraig K. Adler and David M. Dennis

Grobman (1944, p. 266) separated the eastern species of *Plethodon* into the "Eastern Large Plethodons" and the "Eastern Small Plethodons." Of the "Large Plethodons" the largest and, according to Dunn (1917, p. 601; 1926, p. 133) the most primitive, is *Plethodon yonahlossee* Dunn. This species is the largest in the genus; it has the longest legs and the most vomerine teeth. We wish to describe a new *Plethodon* which surpasses *Plethodon yonahlossee* in each of these features, and is markedly different from all known members of the genus.

Plethodon longicrus,* new species

DIAGNOSIS. A very large *Plethodon* with numerous flecks and/or blotches of chestnut brown pigment on the dorsum; white flecking on head, body, limbs, and tail, most concentrated on sides from angle of jaw to groin; long, well-developed legs; a low number of intercostal spaces between adpressed limbs (in adults, lack one space to overlap one space); and a high number of vomerine teeth (in adults, 26 to 53 total).

TYPE LOCALITY. The northeast slope of Bluerock Mountain, below the Bat Caves, Rutherford County, North Carolina, approximately 0.8 mile ESE of Bat Cave (city), at an elevation of about 1645 feet above sea level (data according to USGS map, Bat Cave quadrangle, 1946 edition; elevation recorded by us with an United States Corps of Engineers field altimeter). See plate II, figure 3.

RANGE. At present known only from the vicinity of the type locality, at elevations from about 1430 to 1710 feet above sea level (see figure 1).

DESCRIPTION OF THE HOLOTYPE. USNM 145658, an adult male collected at the type locality, August 28, 1961, by Kraig K. Adler, David M. Dennis, and Steve G. Tilley. Costal grooves 16; adpressed limbs touch; total length 194.5 mm; snout to posterior end of vent 90.5 mm; head length (to gular fold) 21.5 mm; maximum head width 15.5 mm; anterior angle of eye to nostril 5.5 mm; length of eye 4 mm; length of forelimbs (from insertion to tip of longest toe) 23 mm; length of left hindleg 25 mm; length of right hindleg 27 mm; fingers 3-2-4-1 (longest to shortest); toes 4-3-2-5-1 (longest to shortest). Head with nasolabial grooves, at the lower end of which are small protuberances; outline of upper jaw concave as seen from the side; angle of jaw posterior to rear angle of eye; both eyelids fitting under a fold of skin behind; a groove from eye to gular fold; a groove from this down behind angle of jaw; mental gland large and truncate posteriorly, width 9 mm, length 6 mm. Vomerine teeth 22 on the left, 21 on the right, beginning behind outer border of nares, the two rows separated in midline by a distance about equal to the width of a naris, and from the palatine teeth by slightly more than the width of a naris; palatine teeth in two patches, beginning at middle of eye sockets, length 2 1/2 times width; tongue broad and flat, nearly filling the floor of the mouth, plicae radiating from a medial point near the posterior margin. Vent papillate internally. Tail rounded throughout its length except at the tip where it is slightly compressed laterally. Color black above, with white flecking on head, body, and tail, this overlaid by flecking and blotches

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*From the Latin: *longus*, long + *crus*, leg.

of chestnut brown pigment; venter dark gray scattered with white flecks, becoming lighter on chest and tail; cloacal lips and gular region lighter, the latter heavily mottled with white flecking; soles of feet flesh color; peritoneum heavily pigmented (melanophores); mental gland lighter than gular region.

DESCRIPTION OF THE ALLOTYPE. UMMZ 123054, an adult female with the same data as the holotype. Differs from the holotype as follows: total length 171 mm; snout to posterior end of vent 89 mm; tail regenerated; head length 21 mm; head width 14.5 mm; angle of eye to nostril 5 mm; length of eye 3.5 mm; length of forelimbs 22 mm; length of hind limbs 27 mm; protuberances at lower end of naso-labial groove not as pronounced as in holotype; no mental gland. Vomerine teeth 22 on the left, 24 on the right; separated from the palatine teeth by twice the width of a naris. Lining of cloaca grooved vertically, not papillate. Coloration similar to holotype, except that dorsal white flecking is more profuse on the flanks and unregenerated portion of tail, slightly more chestnut pigment on the dorsum; venter has more and larger white flecks, gular region slightly darker than in holotype; peritoneum heavily pigmented.

DESCRIPTION OF A JUVENILE. MCZ 34962, a juvenile female collected at the type locality, September 7-8, 1961, by Kraig K. Adler, David M. Dennis, and Corson J. Hirschfeld. Total length 81 mm; snout to posterior end of vent 41 mm; adpressed limbs overlap 3 costal spaces; head length 10.5 mm; head width 7 mm; angle of eye to nostril 2 mm; length of eye 2.5 mm; length of forelimbs 12 mm; length of hindlimbs 14 mm. Vomerine teeth 13 on the left, 8 on the right. Coloration as in holotype, except that venter and gular regions are lighter; chestnut pigment reduced to a few flecks. Peritoneum heavily pigmented. Soles of feet same color as venter.

PARATOPOTYPES. All specimens listed are from the vicinity of the type locality (see figure 1).

August 28, 1961, Kraig K. Adler, David M. Dennis, and Steve G. Tilley, collectors. AMNH 67677, ANSP 26734, CM 38009, MVZ 72661-2, UIMNH 50346, USNM 145659, 145661, 145663.

September 7-8, 1961, Kraig K. Adler, David M. Dennis, and Corson J. Hirschfeld, collectors. ANSP 26733, CM 38010, CNHM 131271-2, MCZ 34962, UMMZ 123052-3, USNM 145660, 145664-5.

November 4, 1961, Kraig K. Adler and Corson J. Hirschfeld, collectors. AMNH 67676, MCZ 34963, UIMNH 50347, USNM 145662.

COLOR VARIATION IN THE TYPE SERIES. Basic coloration as in the holotype, with these variations:

Dorsum. The amount of chestnut pigment varies from a few small flecks to larger blotches or a combination of both, always restricted to the dorsum of the trunk, base of tail, and neck region. Every specimen had some of this pigment in life. In larger specimens the tail becomes progressively browner towards the tip. White flecks (iridophores) are directly proportional in size to the length of the salamander, the largest being found at the base of the tail. Some larger individuals exhibit a band of gray lichen-like markings along the sides from the angle of the jaw to the groin. In preservative, the white and chestnut pigments fade, the latter more rapidly. In some specimens, after two months preservation in formaldehyde and alcohol, the chestnut color is no longer visible, but pale areas are present marking the former extent of this pigment.

Venter. White flecking on the belly is variable, from profuse (AMNH 67676) to almost none (MVZ 72662). Mottling of gular region also variable. Tail lighter than trunk, becoming lighter towards tip.

MORPHOLOGICAL VARIATION IN THE TYPE SERIES. Data for each specimen are listed in table I.

MUSEUM CATALOG NUMBER	FIELD CATALOG NUMBER	SEX	SNOUT TO POSTERIOR END OF VENT	TAIL LENGTH	HEAD		MENTAL GLAND		VOMERINE TEETH	LENGTH OF LEGS				COSTAL SPACES BETWEEN ADPRESSED LIMBS	COSTAL GROOVES	LENGTH OF EYE	ANGLE OF EYE TO NOSTRIL	MELANOPHORES IN PERITONEUM
					length	width	length	width	left/right	forelegs		hindlegs			left/right			(degree)
										left	right	left	right					
UIMNH 50346	2	♂	100	99	22.5	16	7	9.5	30/23	23.5	23.5	27.5	27	+0.5	16/16	4	6	heavy
USNM 145658	17	♂	90.5	104	21.5	15.5	6	9	22/21	23	23	25	27	0	16/16	4	5.5	heavy
MVZ 72662	18	♂	89.5	82+	20.5	14	6	8.5	14/15	22	22	27	27	-1	16/16	3.5	5.5	none
USNM 145662	22	♂	87	94	20	13.5	7	8	18/17	21	21	25.5	25.5	-1	16/16	3.5	5	heavy
MCZ 34963	24	♂	92	105	23	15.5	7	9.5	13/13	23	23	27	26	-0.5	16/16	4.5	6	heavy
CM 38009	1	♀	79	81+	19	13	-	-	14/18	21	21	24	24	-1	16/16	3	4	medium
ANSP 26733	7	♀	101	118	21.5	16	-	-	30/21	23	23	27	27	+1	16/16	4	5.5	light
CNHM 131271	8	♀	97	40+	23	16.5	-	-	18/19	23	23	27	27	+0.5	16/16	3.5	5	light
UMMZ 123054	19	♀	89	82+	21	14.5	-	-	22/24	22	22	27	27	0	16/16	3.5	5	heavy
AMNH 67676	23	♀	101	120	23	16.5	-	-	20/25	24.5	24.5	28.5	28.5	+1	16/16	4.5	5.5	medium
USNM 145665	15	juv	61	63	15	11	-	-	20/21	17	17	20.5	21	-2	16/16	3.5	3.5	light
UMMZ 123053	16	juv	64.5	65	14.5	11	-	-	21/23	17	17	20	20	-2	16/16	3	3.5	medium
MVZ 72661	3	juv	41	38	10	7.5	-	-	12/10	12	12	13	13	-3	16/16	2	3	heavy
AMNH 67677	4	juv	39.5	41	10.5	7.5	-	-	11/14	12	12	14	14	-3	16/16	2	2.5	medium
USNM 145663	5	juv	40	27+	10.5	7	-	-	14/13	12	12	14	14	-3	16/16	2	2	light
USNM 145659	6	juv	36	32.5	9	7	-	-	12/10	11	11	12.5	12.5	-3	16/16	2	2	light
USNM 145660	9	juv	43.5	45	11	8	-	-	17/17	13	13	14.5	14.5	-3	16/16	2	3	medium
CNHM 131272	10	juv	43	44	11.5	8	-	-	14/15	13	13	15	15	-3	16/16	2.5	3	heavy
MCZ 34962	11	juv	41	40	10.5	7	-	-	13/8	12	12	14	14	-3	16/16	2.5	2	heavy
USNM 145664	12	juv	39.5	38.5	10	8	-	-	9/8	12	12	13.5	13.5	-3	16/16	3	2	light
CM 38010	13	juv	42	28+	11	8.5	-	-	15/15	12	12	14	14	-3	16/16	3	2	light
UMMZ 123052	14	juv	48	41	12.5	10	-	-	14/11	12.5	14	17	17	-3	16/16	3	2.5	light
ANSP 26734	20	juv	39.5	30	10.5	8	-	-	12/13	12	12	14.5	14.5	-3	16/16	2.5	3	medium
USNM 145661	21	juv	44.5	41.5	10.5	8	-	-	13/15	12	12.5	14	14	-3	16/16	3	3	heavy
UIMNH 50347	25	juv	42	40	11	8.5	-	-	9/11	12.5	12.5	15	15	-3	16/16	3	3	heavy

TABLE I. List of morphological data for the type series of *Plethodon longicrus*. All measurements are in millimeters.

SEXUAL DIMORPHISM AND SIZE AT MATURITY.

Sexual Dimorphism. As in *Plethodon yonahlossee*, the males of *P. longicrus* have a large protuberance on the upper lip at the lower end of the nasolabial groove. In females (and juveniles) this swelling is present but less pronounced.

TABLE II. Size and total vomerine teeth counts for ten adult *Plethodon longicrus*. All measurements are in millimeters.

SEX	NUMBER OF SPECIMENS	SNOUT-VENT SIZE extremes	SNOUT-VENT SIZE mean	TOTAL VOMERINE TEETH extremes	TOTAL VOMERINE TEETH mean
Male	5	89.5-101	91.8 ± 4.9	26-53	37.2 ± 11.0
Female	5	79-101	93.4 ± 9.4	32-51	42.2 ± 7.6

On the basis of only 10 adults, sexual dimorphism in size and total number of vomerine teeth is barely noticeable (table II); however, these figures are not statistically significant.

Size at Maturity. The gonads of several *P. longicrus*, including the two in the 60-70 mm snout-vent range, were sectioned and examined microscopically. In the young male (UMMZ 123053, 64.5 mm snout-vent), the spermatogonia have not begun active division. In addition, there are no cloacal papillae and no indication of a mental gland. We therefore consider this specimen immature.

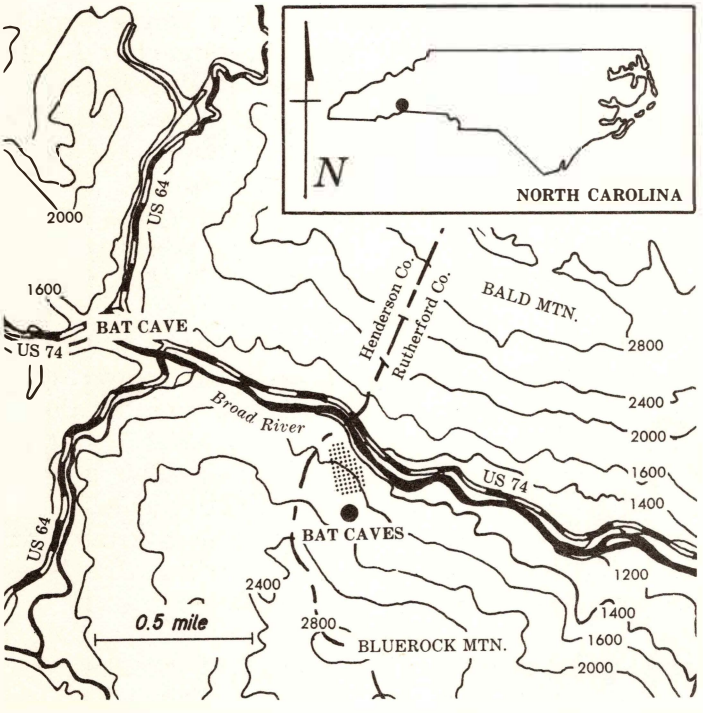

FIGURE 1. Map of the Bat Cave area (from USGS map, Bat Cave quadrangle, 1946 edition). The inset shows the position of the Bat Cave area in North Carolina. Major contour lines are shown. The stippling indicates the known range of *Plethodon longicrus*.

The young female (USNM 145665, 61 mm snout-vent) is more difficult to determine. The ova are very small and do not appear to have begun the first maturation division. However, in the cloaca, there are slight indications of vertical grooves, but not as pronounced as in larger, mature females. On the basis of these data we feel that this female is probably immature. Dr. William F. Hahnert, an embryologist, has kindly examined our series of gonadal slides and concurs with our view. Both of these specimens are listed as immature throughout this paper.

If the above assumptions are correct, it would mean that *P. longicrus* matures somewhat above 65 mm snout-vent in males (the next largest male, USNM 145662, 87 mm snout-vent, is mature) and above 61 mm snout-vent in females (the next largest female, CM 38009, 79 mm snout-vent, is mature).

ECOLOGY.

Parasites. Most of the *Plethodon longicrus* are infested with dermal mites, identified as *Hannemania hegeneri* Hyland by Donald E. Johnston, Curator of the Institute of Acarology, The Ohio State University. *H. hegeneri* was first described (Hyland, 1956) from Florida *Rana pipiens* Schreber, and except for introduction on *Notophthalmus*, *Desmognathus*, and *Eurycea* in the laboratory, has not heretofore been detected on salamanders in the wild (Hyland, 1961, p. 214). These mites are most heavily concentrated on the limbs including feet, but are also found occasionally on the tail, neck, and trunk near leg insertions (cf. plate I, figures 1-2). According to Rankin (1937, p. 217), who worked with a closely related species *H. dunni* Sambon, salamanders are infested only by larval parasites. The adult mite lays its eggs in late summer and the newly-hatched larvae infest the salamanders from about August until the following spring.

Neither Rankin (*op. cit.*, p. 191) nor Pope (1950, p. 93) found dermal mites on *Plethodon yonahlossee*. However, Rankin (*op. cit.*, p. 189) did find *H. dunni* on *P. glutinosus* Green from Durham, North Carolina. Both Dunn and Heinze (1933, p. 122) and Pope and Pope (1951, p. 138) record heavy mite infestation in *P. ouachitae* Dunn and Heinze, and the Popes' description of the infestation sounds very similar to that in *P. longicrus*.

Some of the other salamanders taken with *P. longicrus* are also infested with mites which we assume to be *H. hegeneri* too. These salamanders include *Plethodon jordani melaventris* Pope and Hairston (1 spec.) and *Aneides aeneus* Cope and Packard (3 spec.).

Habits and Habitat. *Plethodon longicrus* has been found at elevations from about 1430 feet to 1710 feet above sea level. Measurements were made with an United States Corps of Engineers field altimeter which was set at a bench mark in Bat Cave (city) immediately before the measurements were taken on November 4, 1961. The instrument was found to be high by 20 feet when rechecked at the same bench-mark after the readings had been taken. Specimens were found only in an area from about 250 to 600 feet from the Broad River (not to be confused with the separate French Broad River), even though collections outside these limits in both directions were made (see figure 1). Small intermittent streams, seepages, and springs are numerous near and among the outcrops where *P. longicrus* was taken. Our studies were not systematic enough to determine whether or not *P. longicrus* is restricted to a zone near water.

On November 4, 1961, we took temperature readings in crevices from which *P. longicrus* had been taken minutes beforehand. These ranged from 57.5° to 60.0°F (mean of three stations, 58.7 ± 1.3°F). The average annual temperature in the Bat Cave area is about 58-60°F (United States Atomic Energy Comm., 1953, p. 398). Inhabited crevices were always moist, but not wet. *P. longicrus* was always found in deep crevices and fissures, except for one small individual (UIMNH 50347, 42 mm snout-vent) which we took on a lichen-moss covered boulder at the entrance to a small cave at 1430 feet. This was at 5:00 A.M. during a light rain. The average annual precipitation in the Bat Cave area is 55-60 inches (United States Atomic Energy Comm., *op. cit.*, p. 380).

Specimens of *P. longicrus* were taken on August 28 (11 spec.), September 7-8 (10 spec.), and November 4 (4 spec.), 1961. On March 16, 1962, we found *Gyrinophilus* and *Desmognathus* near the Bat Caves, but no *Plethodon*.*

*Since the above was written, on April 2, 1962, we collected one juvenile *P. longicrus* (DMD-KKA, 42 mm snout-vent) in a small cave at 1450 feet elevation in the vicinity of the type locality. This specimen all but lacked the chestnut pigment on the dorsum. Invertebrate life was more plentiful than on March 16th; we saw several dozen cave crickets, a few slugs and snails. The cliff faces were more moist than on March 16th. We visited the area again two days later (April 4) with J. C. Nicholls, Jr., and found only *Desmognathus*.

Except for the one juvenile mentioned above, all specimens of *P. longicrus* were taken from deep crevices in the rockfaces of granite gneiss. They were most easily captured by teasing them out of the crevices with a stick. Several individuals were pugnacious and bit at the stick. Only about half of the specimens seen could be captured in this manner - a fact that will contribute to saving many of these salamanders from the museum shelf. *P. longicrus* is certainly one of the most agile plethodons. Night collecting with headlamps on August 28, 1962 did not net a higher number of specimens for the time spent. We examined several niches for *P. longicrus* - seepages, under logs, and in leaf litter, and except for the cliff faces mentioned, no specimens were secured. When caught, they were difficult to hold in one's hand, especially larger individuals. These could easily force their way through our fingers. *P. longicrus* is about as slimy as *P. yonahlossee*, perhaps a bit moreso, but not as slimy as *P. glutinosus*, in our estimation.

Weller (1930a; 1930b; 1931, pp. 24-5) made collections of the fauna of the general area. The only species he recorded from the immediate vicinity of the Bat Caves was *Aneides aeneus*. We found *aeneus* (4 spec.) on two occasions in direct association with the new form. One was found but a few inches from a large *longicrus* in the same crevice. We have examined the one extant *P. glutinosus* collected by Weller at nearby Chimney Rock Camp (CMNH 525, 81.5 mm snout-vent) and find that it is definitely *glutinosus* as published and not *longicrus*. The only other herpetofauna we found inhabiting the same cliff faces were *Plethodon jordani melaventris* (1 spec.), *Desmognathus ochrophaeus carolinensis* Dunn* (3 spec.), *Rana sylvatica* LeConte (1 spec.), and *R. palustris* LeConte (2 spec.). The two *palustris* were taken with *P. longicrus* in a cave at 1430 feet. The cave habits of this frog have been noted by several other writers (Bailey, 1933, p. 213; Brown and Boschung, 1954, p. 226; Brode, 1960, p. 233). In nearby seepages and springs *Desmognathus m. monticola* Dunn and *Gyrinophilus danielsi dunni* Mittleman and Jopson were taken. The following invertebrates were also commonly found in the crevices with *P. longicrus*: spirobolid millipedes, *Narceus* sp. (= *Spirobolus* of American authors), slugs, *Philomycus carolinianus* Bosc, and cave crickets, *Ceuthophilus g. gracilipes* Haldeman. Some or all of these no doubt serve as food for *P. longicrus*.

According to Braun (1950, pp. 195-221) the Bat Cave area lies within the "oak-chestnut" region of the Eastern Deciduous Forest. Because no extensive sampling of the flora was made, only those species noted are listed here. The canopy is primarily composed of slippery elm, *Ulmus fulva* Michx., tulip-poplar, *Liriodendron tulipifera* L., mountain-maple, *Acer spicatum* Lam., red maple, *A. rubrum* L., chestnut-oak, *Quercus montana* Willd., chinquapin-oak, *Q. muhlenbergii* Engelm., red oak, *Q. rubra* L., and hickory, *Carya* sp. This cover is quite dense and permits little passage of light on to the cliff faces. The understory is primarily dogwood, *Cornus* sp., with hemlock, *Tsuga canadensis* (L.) Carr, replacing it in moist areas and coves. The shrub layer is predominately made of mountain-laurel, *Kalmia latifolia* L., and greal laurel, *Rhododendron maximum* L. (see plate II, figures 1-2). The other plants include winter-grape, *Vitus vulpina* L., rock-polypody fern, *Polypodium virginianum* L., and snakeroot, *Sanicula* sp., at the base of the cliffs, while the cliff faces are covered with mosses and lichens such as *Mnium* sp. and *Peltigera* sp., plus alumroot, *Heuchera* sp. The latter plant, along with several others named (e.g. *Rhododendron*), indicate a moist, slightly acidic soil.

Specimens of these plants have been deposited in the herbarium of Ohio Wesleyan University, Delaware, Ohio.

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*We are aware that Valentine (1961, p. 319) would restrict this name to high altitude populations.

RELATIONSHIPS AND DISCUSSION. Because of its large size and low number of costal grooves, *Plethodon longicrus* is a member of the Eastern Large Plethodon group (Grobman, 1944, p. 276; Highton, 1956, p. 80). Within this group it is most closely related to *P. yonahlossee*, for reasons discussed below.

Habitat and Geography. As mentioned earlier, *P. longicrus* seems to be restricted to a zone of cool, moist fissures and crevices in an extensive outcrop of metamorphic rock (granite gneiss). On the other hand, *P. yonahlossee* is usually found on wooded hills, in valleys, ravines, and open pastureland (Pope, 1950, pp. 87-9). However, we took six *yonahlossee* just northeast of Boone, North Carolina (DMD-KKA), in crevices in a sedimentary rock outcrop made by blasting for roads. This habitat seems to approach that of *longicrus* more closely than any mentioned in the literature. However, it is still considerably different from the Bat Cave area. The Boone locale is poorly shaded, the outcrop is sedimentary, not extensive, artificial, only a few feet from the road, and the fissures are not deep. At Bluerock Mountain (Bat Cave), the outcrop is well shaded, metamorphic, very extensive, natural, the fissures are extremely deep, and the localities for *longicrus* are several hundred feet from the nearest road.

Pope (1950, pp. 88-9) found *yonahlossee* in a variety of habitats in three localities in the northern range of the species. These were not restricted to a zone near water. Working at White Top Mountain and Mt. Rodgers, Virginia, Organ (in *litt.*, 20.ii.62) found *yonahlossee* more common within 100 feet of water, but definitely present in some numbers "in forest areas in excess of . . . 250 feet from the water."

Hairston (1949, p. 55), while working in the Black Mountains only about 20 miles north of Bluerock Mountain, found that *yonahlossee* is "restricted to a zone within 100 feet" of streams. "Streams," in this case, mean "any running surface water [and include] some pretty small 'trickles'" (Hairston, in *litt.*, 13.ii.62). However, Bailey (1937, pp. 2-3) worked even further south (and nearer Bat Cave) and did not note this fact. Nevertheless, Hairston's studies may indicate that *yonahlossee* is more restricted ecologically in the southern part of its range. As mentioned above, our survey of *P. longicrus* was too unsystematic to make any comments on this aspect of the ecology of the species.

Altitudinally, *yonahlossee* is found between 2500 and 5700 feet (Pope, 1950, p. 81). The specimen listed by Hairston (1949, p. 56) from Mortimer, North Carolina, at 1500 feet, may be due, as Hairston suggests, to accidental transport downstream during a flood. Two plethodons closely related to *yonahlossee* inhabit the Ouachita Mountains of Oklahoma and Arkansas. These are found at lower altitudes: *Plethodon ouachitae* (1700-2825 feet) and *P. caddoensis* Pope and Pope (950-1200 feet), according to Pope and Pope (1951, pp. 134, 149). We found *longicrus* between 1430 and 1710 feet. If *P. longicrus* is related to *yonahlossee* (as we believe it is), this would mean that a high and a low altitude species of the *yonahlossee* group is found in both the Ouachita Mountains and in the Southern Appalachians.

The southernmost record for *P. yonahlossee* is the vicinity of Swannanoa (Bailey, 1937, p. 2), although Hairston and Pope (1948, p. 276) indicate a range slightly south of there, and south of the Swannanoa River. Thus, *yonahlossee* is known from localities about 10 miles north of Bat Cave. Collections were made on three occasions between Bat Cave and Swannanoa; no specimens of either species were found. This area should be hunted extensively for these salamanders since collections from this narrow gap will shed much light on the relationships of the two forms.

Coloration and Pigment Structure. To a casual observer, *P. longicrus* looks strikingly like *P. glutinosus*, especially in juveniles where the chestnut pigment is not particularly noticeable. However, examination of living specimens of all sizes reveals chestnut blotches and/or flecks on the dorsum, similar in color-

ation to the chestnut stripe of *yonahlossee* and the chestnut blotches of *ouachitae*. When compared with the color plate in Conant (1958, plate 32) living specimens of *longicrus* have a darker shade of chestnut pigment than shown in Conant's figure of *yonahlossee* and approach the color of *ouachitae* (see plate I, figures 1-2).

We have examined iridophore structure in *P. longicrus* under 54 magnifications and compared it with the illustrations in Hairston and Pope (1948, p. 270) as well as with our own material of *yonahlossee* and *glutinosus*. Unlike these authors who show a considerable difference between the iridophores of *yonahlossee* and *glutinosus*, we find that the iridophores of these two species as well as those of *longicrus* are very similar and all show some variation. They seem too similar and variable to provide a diagnostic character. Later, Hairston (1950, p. 270) did state that the differences are not diagnostic as thought previously.

According to Highton (1956, p. 90), *Plethodon wehrlei* Fowler and Dunn is the only Eastern Large Plethodon that possesses melanophores in the peritoneum. In our studies, however, we have found them in some specimens of *P. yonahlossee*, *P. glutinosus*, *P. w. wehrlei*, *P. jordani metcalfi* Brimley, *P. wehrlei dixi* Pope and Fowler (all DMD-KKA), and *P. longicrus*. Highton (in *litt.*, 27.xii.61) informs us that he has subsequently found them in some *glutinosus*. Of the 25 specimens of *longicrus*, all but one possess peritoneal melanophores (table I). In Bailey's series of *yonahlossee* from Swannanoa (UMMZ 75493-5, 76274) we find this pigment in 17 of the 33 specimens in the series. In addition we find it in *yonahlossee* from Boone, North Carolina (DMD-KKA). In a series of 41 *glutinosus* from McDowell and Henderson counties, North Carolina (UMMZ 52631-72, 98595), none possess this pigmentation (we did find it in several series of *glutinosus* from Ohio). Likewise, the series of 25 *ouachitae* from various locales (UMMZ 77381-2, 77793, 77795, 117057) examined by us possess none. However, we do find it in a small series of *ouachitae* from Polk County, Arkansas (BDV).

Some juveniles of both *P. longicrus* and *P. yonahlossee* possess melanophores on the sides of the tongue. Five of the fifteen juvenile *longicrus* (39.5 to 43 mm snout-vent) have this pigment, and three of fourteen juvenile *yonahlossee* (32 to 45 mm snout-vent) from Swannanoa have some (UMMZ 75493-5, 76274). Although we examined small series of some other Eastern Large Plethodons (*P. glutinosus*, *P. w. wehrlei*, and *P. w. dixi*, all juveniles), none have this pigment. In addition, some juvenile *yonahlossee*, *glutinosus*, and *longicrus* also possess pigment on the palate. However, our series are small. The only other juvenile Eastern Large Plethodons we have examined for this character are *wehrlei* and *dixi* (DMD-KKA), neither of which has this pigment.

In Bailey's series of *P. yonahlossee* from Swannanoa, which included 14 juveniles, the largest specimen that still has an indication of dorsal spots is 36 mm snout-vent. In this specimen there is a faint indication of only one spot. Our smallest juvenile *longicrus* (USNM 145659) is 36 mm snout-vent and does not seem to have any indication of juvenile red spots (in life or after preservation), although in life it did possess the small flecks of chestnut pigment characteristic of this species. We hope to be able to secure smaller juveniles this coming year which should provide more data on the relationships of the two species.

Mental Gland. The mental glands of male *P. yonahlossee* and *P. glutinosus* have been compared with those of *P. longicrus*. The mental glands of *yonahlossee* and *longicrus*, although somewhat different, are more similar in size and shape to one another than either is to that of *glutinosus*. *P. yonahlossee* and *longicrus* agree in having a large, oval gland cluster in contrast to the smaller, more nearly circular gland of *glutinosus*.

Maximum Size and Size at Maturity. The largest *P. yonahlossee* reported is an adult female 189 mm in total length (Hirschfeld, 1962, p. 53); however,

Blair (1957, p. 232) records a *yonahlossee* with a snout-vent of 91 mm, exceeding Hirschfeld's of 85 mm. To our knowledge, the largest *glutinosus* is an adult female 188 mm total length recorded by Orton (1946, p. 107). Our largest *longicrus* is also an adult female, 221 mm in total length (AMNH 67676). Thus, the new form is the largest member of the genus. In the Family Plethodontidae, it is rivaled only by several Central American forms and equalled in North America by the recently described *Phaeognathus hubrichti* Highton. Bishop (1943, p. 368) records a 219 mm *Gyrinophilus p. porphyriticus* Green.

In *P. glutinosus*, males mature at about 49 mm snout-vent, females at about 57 mm (Pope and Pope, 1949, p. 255); in *yonahlossee*, the same figures are about 56 mm and 61-64 mm, respectively (Pope, 1950, p. 94); and in *ouachitae*, 48 mm and 52 mm, respectively (Pope and Pope, 1951, p. 140). Our data for *longicrus* (see above under "Size at Maturity") indicate that a 61 mm female and a 64.5 male are still immature. Possibly, *longicrus* matures at a larger size than any of the three species mentioned above.

Adpressed Limbs. Adpressing the limbs seems to be the best and most rapid method of distinguishing preserved *P. longicrus* (which has lost the chestnut pigment) from other plethodons, particularly *glutinosus*. As can be seen from figure 2, the three species can easily be separated on the basis of this character. There is no overlap between *longicrus* and either *yonahlossee* or *glutinosus;* however, there is overlap between *yonahlossee* and *glutinosus*.

Vomerine Teeth. Pope (1949, p. 253) records 35 as the maximum number of total vomerine teeth in *P. glutinosus* and 43 as the maximum in *yonahlossee* (Pope, 1950, p. 103). The highest number we find in *longicrus* is 53 (UIMNH 50346, male), which is the highest number recorded for the genus. These maxima are only in part a reflection of greater size, for even in similar-sized specimens, *longicrus* tends to have more teeth than the other two species (see figure 2).

We have compared the slope of the vomerine teeth graph of *P. yonahlossee* in Pope (1950, p. 103) with our data for the same species from Swannanoa (UMMZ 75493-5, 76274). It appears that Pope's series of 125 specimens from three localities in the northern part of the range of *yonahlossee* has a slightly lower vomerine teeth count proportionate to snout-vent than those in the Swannanoa series from the southern part of the range. These data suggest that a cline exists in the vomerine teeth number of this species, the number of teeth increasing southward. In addition, we have compared the vomerine teeth counts of our series of 25 *longicrus* with both graphs of *yonahlossee*. When these are all plotted on the same graph there is considerable overlap. However, upon careful examination, it appears that Pope's series has a low count, the Swannanoa series a slightly higher count, and the *longicrus* series slightly higher than the Swannanoa *yonahlossee* (figure 3), especially in juveniles. Tooth loss in adult males may account for a leveling off of the graph in adults. In *longicrus* were related subspecifically to *yonahlossee*, it would fit the cline in vomerine teeth suggested above.

We have also compared the *P. longicrus* vomerine teeth graph with those of *glutinosus* (Pope and Pope, 1949, p. 253, 125 specimens), *ouachitae* (Pope and Pope, 1951, p. 147, 125 specimens), and *caddoensis* (Highton, 1956, p. 85, 39 specimens). As indicated by our own graph (figure 3) the counts for *glutinosus* average well below those of *longicrus*, with no overlap. The same is also true when compared with the Popes' graph (1949, p. 253) for the same species.

When the Pope and Pope (1951, p. 147) series of *ouachitae* are plotted with Pope's (1950, p. 103) *yonahlossee*, they seem to overlap completely; however, *ouachitae* has a slightly wider spread above and below that of *yonahlossee*. In a series of 25 *ouachitae* which we examined (UMMZ 77381-2, 77793, 117057), the counts average slightly lower than those reported by Pope and Pope (1951, p. 147). Highton's (1956, p. 85) data for 39 *caddoensis* were also plotted with the above. While there is considerable overlap, the *caddoensis* counts are on the average pro-

portionately higher than either *ouachitae* or *yonahlossee* and approach *longicrus*. It is interesting to note that both lower altitude forms of this group (*caddoensis* and *longicrus*) have higher vomerine teeth counts than do the high altitude forms (*ouachitae* and *yonahlossee*).

Origin. One of the reasons for the postulated primitiveness of *P. yonahlossee* is its similarity, particularly in coloration, to *ouachitae* of Oklahoma and Arkansas. Apparently the ancestor of these two species was at one time found throughout much of eastern North America, at least in an area between the Ouachita Mountains and the Southern Appalachians, the present distribution being due to elimination of the species in most of its former range.

We think that the coloration of *longicrus* more closely approaches that of *ouachitae* than that of *yonahlossee*. In *longicrus* and *ouachitae* the chestnut pigment consists of blotches, whereas in typical adult *yonahlossee* it forms a broad dorsal stripe. According to Pope and Pope (1951, p. 143) 15% of their series of *ouachitae* have the chestnut pigment covering "all or nearly all of the back," a condition approaching that of *yonahlossee*. Therefore, on the basis of pigment and general coloration (e.g. white flecking on the dorsum), *ouachitae* is intermediate between the other two forms in color pattern. According to Dunn (1917, p. 601), *yonahlossee* is the most primitive member of the genus *Plethodon*, based on four characteristics: (1) a low number of costal grooves; (2) a dorsal pattern; (3) a large number of vomerine teeth; and (4) a large size. *P. longicrus* satisfies all of these criteria in each case, as well or better than any other member of the genus. *P. longicrus* has 16 costal grooves, the lowest number normally recorded for the Eastern Plethodons. However, this number is shared by most of the Eastern Large Plethodons and *P. welleri* Walker. The dorsal pattern has been discussed above. *P. longicrus* not only has the highest number of vomerine teeth recorded for the genus, which is partly a reflection of its large size, but also the highest number of vomerine teeth proportionate to length. In addition, the size of *longicrus* (221 mm total length) easily makes it the longest *Plethodon* known. Also, the extremely long legs seem to indicate an unspecialized condition and thus add to the postulated primitiveness of the new form. Therefore, *longicrus* seems to be the most primitive member of the genus.

As we have indicated in figure 2, *longicrus* has extremely long legs, proportionately longer in fact than any other member of the genus. The species that most closely approaches it is *yonahlossee*. In number of vomerine teeth, again *longicrus* is most closely approached by *yonahlossee* (figure 3). Because of these facts, a similarity in coloration, and close proximity of ranges (except altitude?), it seems most logical to us that *yonahlossee* was derived from *longicrus* or pre-*longicrus* stock. It is also possible that *ouachitae* was derived from this same stock. We have not personally examined any *caddoensis* and are not sure of its relationship to the other forms.

FIGURE 2. (opposite page) Graphic relationship between snout-vent and adpressed limbs for three species of *Plethodon*. Material used as follows: *P. glutinosus*, Henderson and McDowell counties, North Carolina (UMMZ 52631-42, 52655-72, 98593 [11 specimens]); *P. yonahlossee*, Buncombe County, North Carolina (UMMZ 75493 [3 specimens], 75494 [9 specimens], 75495 [20 specimens], 76274 [2 specimens]); *P. longicrus*, Rutherford County, North Carolina (the type series, listed in table I). Some of the juveniles could not be plotted because of identical characters.

FIGURE 3. (opposite page) Graphic relationship between snout-vent and total vomerine teeth for three species of *Plethodon*. Material as in figure 2.

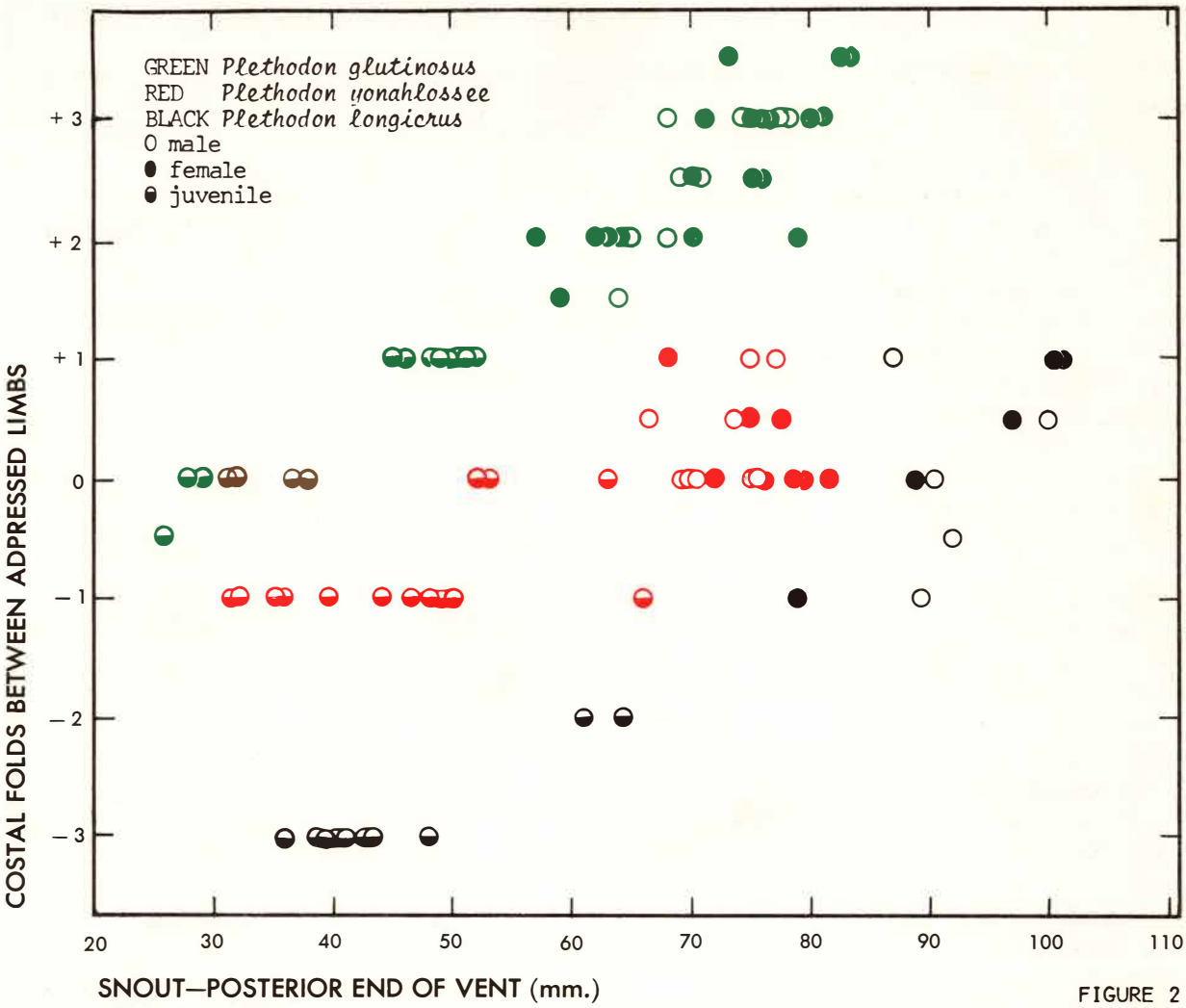

FIGURE 2

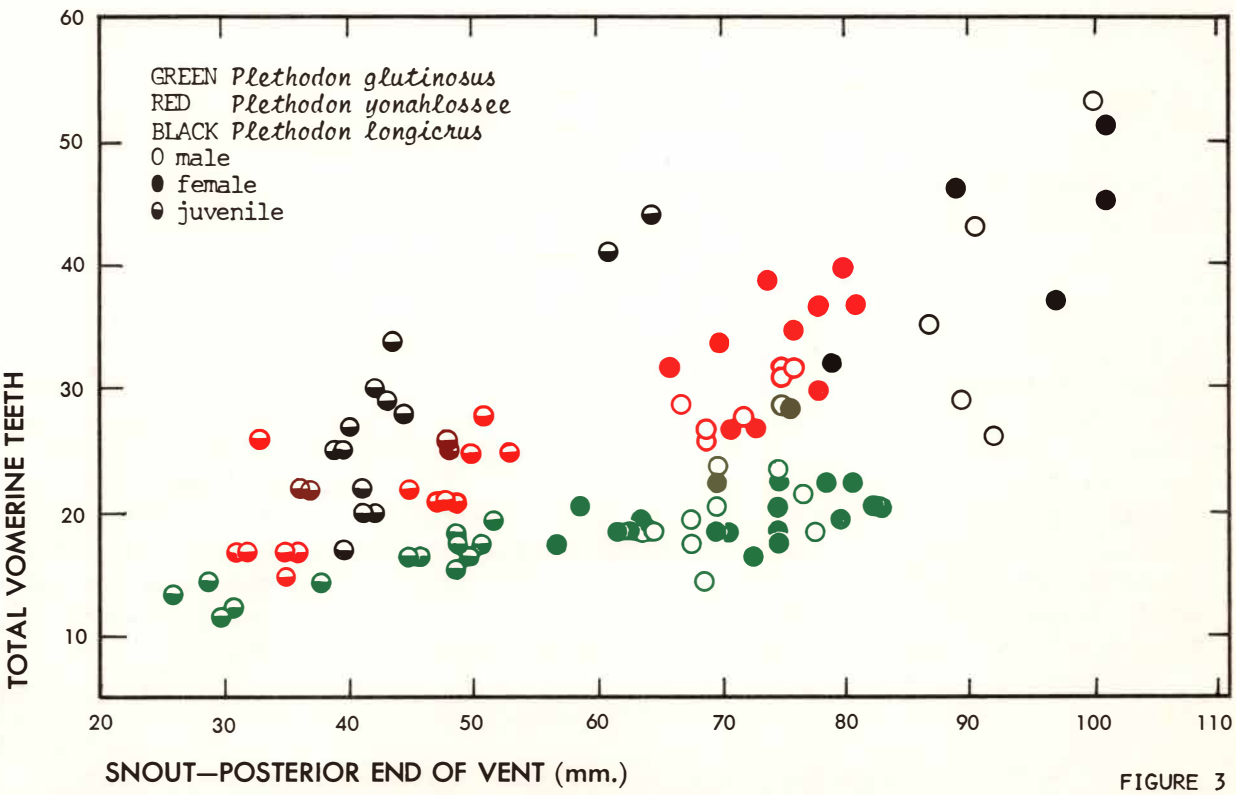

FIGURE 3

MATERIALS AND METHODS. Museum abbreviations referred to in this paper are as follows:

AMNH	American Museum of Natural History, New York 24, New York
ANSP	Academy of Natural Sciences, Philadelphia 3, Pennsylvania
BDV	Barry D. Valentine, Department of Zoology, The Ohio State University, Columbus 10, Ohio
CM	Carnegie Museum, Pittsburgh 13, Pennsylvania
CMNH	Cincinnati Museum of Natural History, deposited at The University of Cincinnati, Cincinnati 21, Ohio
CNHM	Chicago Natural History Museum, Chicago 5, Illinois
DMD-KKA	David M. Dennis-Kraig K. Adler, deposited at the Department of Zoology, The Ohio State University, Columbus 10, Ohio
MCZ	Museum of Comparative Zoology, Harvard University, Cambridge 38, Massachusetts
MVZ	Museum of Vertebrate Zoology, The University of California, Berkeley 4, California
UIMNH	University of Illinois Museum of Natural History, Urbana, Illinois
UMMZ	University of Michigan Museum of Zoology, Ann Arbor, Michigan
USNM	United States National Museum, Smithsonian Institution, Washington 25, D. C.

Specimens were preserved by first killing them in chloretone; then they were fixed in formaldehyde and later transferred to 70% alcohol. All measurements were made within a week after preservation. In order to determine whether or not various methods of preservation caused differences in the amount of shrinkage, we measured specimens of other species which were preserved by the chloretone method described above and compared them with museum specimens preserved by unknown methods (as used in figures 2-3). We did not notice any discrepancy.

Measurements were taken using calipers. The posterior end of the vent was used in making snout-vent measurements. All measurements were taken to the nearest 0.5 mm. In counting vomerine teeth, vacant gaps were not included. All means are accompanied by their standard deviations (= standard error of Pope, 1949, *et seq.*) determined by the following equation:

$$s = \sqrt{\frac{\sum (X - \bar{X})^2}{N - 1}}$$

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New York City) have made useful comments and added unpublished data concerning plethodons. Donald E. Johnston, George W. Wharton, and David H. Stansbery (The Ohio State University) and Edward S. Thomas kindly identified invertebrate material for us. J. Z. Holland (United States Atomic Energy Commission) granted permission to quote from AEC publications. Corson J. Hirschfeld (Cincinnati) assisted on three occasions in the field.

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EXPLANATION OF THE PLATES

PLATE I.

Figure 1. Ventral view of the holotype of *Plethodon longicrus*, USNM 145658, an adult male, from Rutherford County, North Carolina (about natural size).

Figure 2. Dorsal view of the holotype, as in figure 1.

Figure 3. Mouthparts of the holotype, as in figure 1 (about six times natural size).

PLATE II.

Figure 1. General view of the cliff faces at about 1545 feet above sea level, northeast slope of Bluerock Mountain, Rutherford County, North Carolina. All photographs were taken on November 4, 1961.

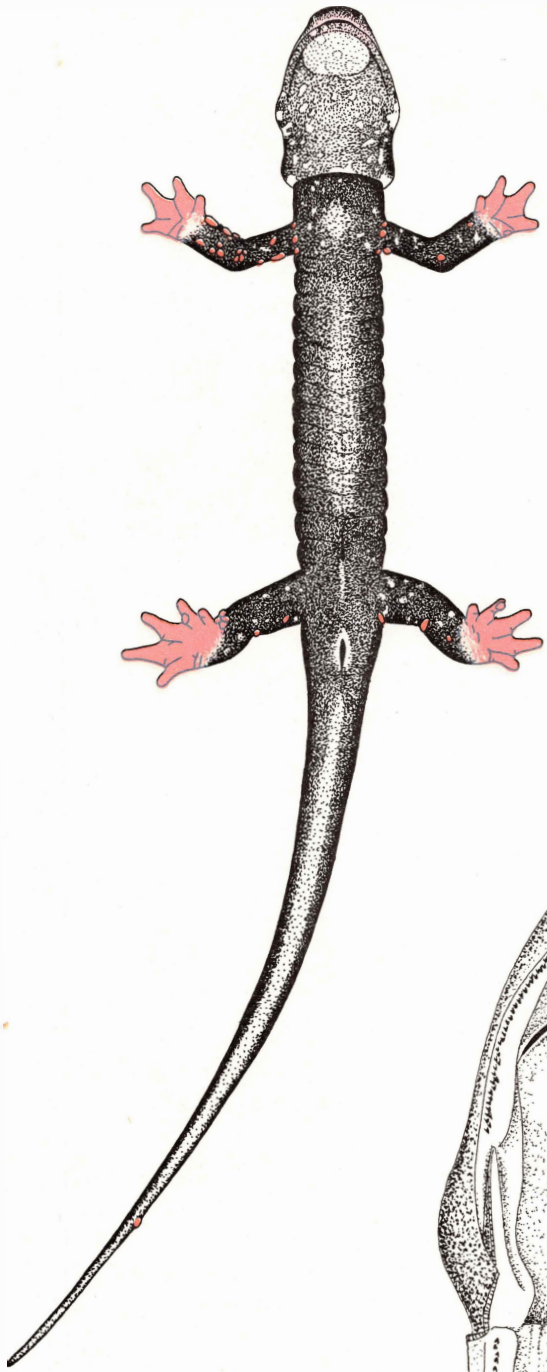
Figure 2. Close-up of the cliff faces in figure 1. Note the abundance of ericaceous shrubs. Specimens of *Plethodon longicrus* were found in the crevices of the cliff face barely visible in the background of this photograph.

Figure 3. The type locality of *Plethodon longicrus*, 1645 feet elevation, Bluerock Mountain, Rutherford County, North Carolina. The holotype was taken in the large horizontal crevice slightly below the center of this photograph.

Kraig K. Adler
David M. Dennis

PLETHODON LONGICRUS

Plate I



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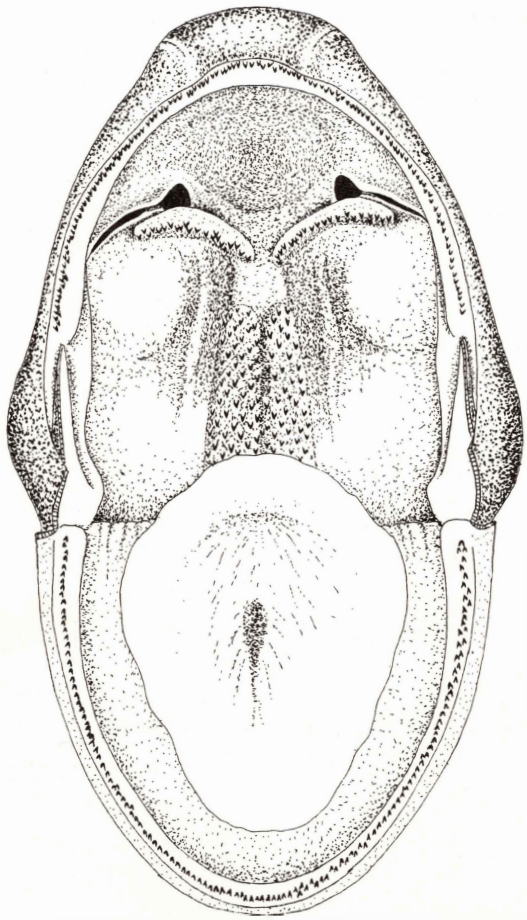

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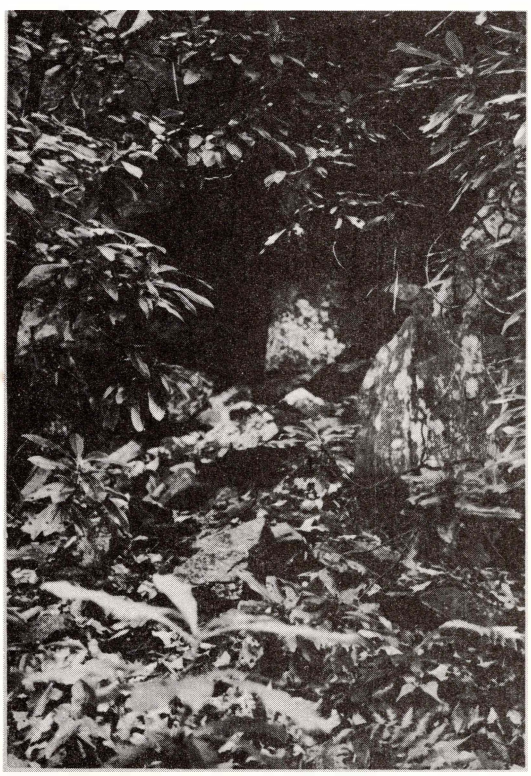
PLETHODON LONGICRUS

Plate II

1



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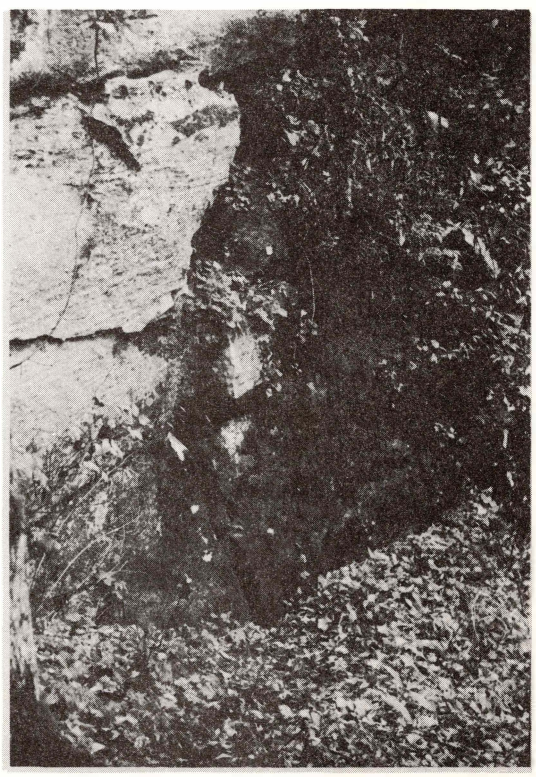

3

ERRATA

page 1, paragraph 5, line 14, "borders"
page 6, paragraph 1, line 7, "1961"
paragraph 3, line 11, "great"
page 9, paragraph 3, line 2, "which have lost"
paragraph 4, line 6, "figure 3"
paragraph 5, line 14, "If"
paragraph 7, line 4, after 77793, add 77795
page 10, paragraph 3, lines 11-12, "criteria, in each case as well"
page 14, line 4, page citation should read 107

Mailed 7 May 1962

THE AUTHOR WOULD GREATLY APPRECIATE REPRINTS OF YOUR ARTICLES IN RETURN